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Relaxation function theory for spin dynamics of strongly correlated layered copper oxide superconductors

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Abstract

We present the relaxation function theory for dynamic spin susceptibility for doped two-dimensional S = 1/2 Heisenberg antiferromagnetic (AF) system in the paramagnetic state as obtained by means of the Mori-Zwanzig projection operator procedure to the t-J model. The results of the calculations are discussed in connection with the peculiar properties of layered copper oxide high-temperature superconductors (high-T c). These include the neutron resonance peak, pseudogap properties, ω/T scaling, and the temperature and doping dependence of plane copper and oxygen nuclear spin-lattice relaxation rates (NSLRR). Particularly, the role of AF short range order, its evolution with doping and saturation of AF correlation length at low temperatures, is highlighted in view of the dynamic spin response of high-T c up to optimal (maximum T c) doping. The contribution from spin diffusion to relaxation rates is evaluated and is shown to play a dominant role in plane oxygen NSLRR of lightly doped (~3% holes per copper site) high-T c at low temperatures. It is shown that the spin-wave-like theory is able to reproduce the main features of spin dynamics in high-T c as observed experimentally.

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